Jan 10th, 12:00 AM

13. Mathematics

Northeastern State University

Abstracts from the 2016 Oklahoma Research Day

Held at Northeastern State University

05. Mathematics and Science

13. Mathematics

05.13.01 Oligopoly

Argyros,Ioannis *Cameron University*

Panta,Sagun *Cameron University*

Oligopoly is a state of industry where firms produce homogeneous goods (or close substitutes) and sell their products in a homogeneous market. We present some existence and uniqueness of equilibrium results in oligopoly markets.The results also relate the equilibrium problem to fixed point problems and nonlinear complementarity problems.

05.13.02 Competition between a nonallelopathic phytoplankton and an allelopathic phytoplankton species under predation

Kengwoung-Keumo,Jean-Jacques *Other*

We propose a model of two-species competition in the chemostat for a single growth-limiting, nonreproducing resource that extends that of Roy(2009). The response functions are specified to be Michaelis-Menten, and there is no predation in Roy's work. Our model generalizes Roy's model to general uptake functions. The competition is exploitative so that species compete by decreasing the common pool of resources. The model also allows allelopathic effects of one toxin-producing species, both on itself (autotoxicity) and on its nontoxic competitor (phytotoxicity). We show that a stable coexistence equilibrium exists as long as (a) there are allelopathic effects and (b) the input nutrient concentration is above a critical value. The model is reconsidered under instantaneous nutrient recycling. We further extend this work to include a zooplankton species as a fourth interacting component to study the impact of predation on the ecosystem. The zooplankton species is allowed to feed only on the two phytoplankton species which are its perfectly substitutable resources. Each of the models is analyzed for boundedness, equilibria, stability, and uniform persistence (or permanence). Each model structure fits very well with some harmful algal bloom observations where the phytoplankton assemblage can be envisioned in two compartments, toxin producing and non-toxic. This work advances knowledge in understanding the crucial functions of allelopathy in food webs.

05.13.03 Sports Betting in the NFL: Are the Winners Experts or Lucky?

Norris,Caleb *University of Central Oklahoma*

Sports betting markets provide a unique opportunity to test market efficiency and in this case, study the presence of experts in forecasting sports outcomes. Research on sports betting experts is important because of its similarity to that of a financial analyst and how “expertly” they select stocks or investments. Can top financial analysts outperform the rest of their competition by selecting well-performing investments? This paper uses a unique panel data set of individual NFL sports bettors in a season long contest known as the Las Vegas SuperContest. The contest is used to track the picks of bettors against the spread on games throughout the 2014 NFL regular season. This paper tests if the leaders in the contest are experts in sports betting or just experiencing a short-term lucky streak. For example, do the top 20% of bettors at the midway point of the season outperform the bottom 80% of over the last half of the season? Results from a single week of picks in the last half of the season indicate that there is no significant difference between the win percentages for the top performers and the remaining contestants. However, when examining the last half of the season as a whole, there is a significant difference between their win percentages. These results indicate that expert sports bettors can be identified over longer time horizons.

05.13.04 Sequences of Line Graphs

Balch,Brenden *University of Central Oklahoma*

Lane-Harvard,Liz *University of Central Oklahoma*

Milligan,Thomas *University of Central Oklahoma*

A graph is a mathematical object that consists of two things, a set of edges and a set of vertices. A tree is a graph that has at least two vertices, and each vertex is connected by at least one path. Line graphs of trees will be of interest for us. Simply put, we construct line graphs by associating edges from the original graph with vertices of our new line graph. New edges are then determined by the adjacency of the edges of the original graph. There is very little known about sequences of vertices on line graphs. Our goal with this project is to construct such sequences. We will try to put these sequences in closed form. With this, we will be able to determine the number of vertices of the nth line graph of certain trees. We currently have results for the sequence of line graphs of a star graph, and we will continue to work on variations of star graphs.

05.13.05 The Existence of Solutions for a Class of Even Order Differential Equations

Brumley,Daniel *University of Central Oklahoma*

Hopkins,Britney *University of Central Oklahoma*

Karber,Kristi *University of Central Oklahoma*

Milligan,Thomas *University of Central Oklahoma*

We outline a method for proving the existence of positive solutions to an even order differential equation satisfying right focal boundary conditions. Beginning with a transformation of the even order boundary value problem into a system of second order differential equations satisfying homogeneous boundary conditions, our method culminates in successive applications of the Guo-Krasnosel'skii Fixed Point Theorem to produce the desired result.

05.13.06 The CCA Urban ACT Prep Program

Brumley,Daniel *University of Central Oklahoma*

Lawrence,Jacintha *University of Central Oklahoma*

Hopkins,Britney *University of Central Oklahoma*

Karber,Kristi *University of Central Oklahoma*

Many studies show a positive correlation between ACT scores and level of family income. In the Oklahoma City Public School district, for instance, students from low-income families tend to have lower scores than students from average income families. In 2014, students from Douglass Mid-High School, which is based in a historically low-income area of Oklahoma City, scored 3 points lower than the district's average. To combat this problem, the CCA Urban ACT Prep Program was formed in 2015. The project seeks to prepare prospective college students for the mathematics portion of the ACT exam by providing tutoring sessions tailored to meet college readiness standards. In this poster, we present a preliminary report based on a semester of work with the students.

05.13.07 A Comparison of Robust Linear Regression Methods

Li,Hong *Cameron University*

Poudel,Abhaya *Cameron University*

Kengwoung-Keumo,Jean-Jacques *Cameron University*

Background:Linear regression is one of the most popular and widely used models for analyzing the effect of explanatory variables on a response variable. Linear regression has widespread applications in various fields of study such as biomedicine, finance, economics, environment science and physics. The Ordinary Least Squares (OLS) method has been generally adopted to estimate the regression parameters. However, the presence of an outliers and/or influential observations greatly reduces the accuracy of parameter estimates of OLS method. Robust regression methods such as LTS-estimate, S-estimate, M-estimate and MM-estimate were proposed and have been used in the presence of outliers. Tabatabai et. al. introduced a new model, TELBS robust regression method, in 2012. Objectives:The study aims to compare the accuracy of TELBS estimates of regression parameters in comparison with OLS, LTS, S-estimate, M-estimate and MM estimate in the presence of outliers. Method:We identify the outliers using diagnostic graphs and measures. We compare the performance of TELBS estimates with other robust methods estimate using one real data set which contain outliers. We used R and Mathematica for all computations and simulations. Results:MM-estimate and TELBS method perform better than other approaches for the data set examined in this study. The parameter estimates obtained by TELBS method are very close to those obtained by OLS with the absence of outliers in the data set.

05.13.08 Working with Mathematical Deficiencies through ACT Preparation

Schnelle,Natalie *University of Central Oklahoma*

Bayles,Esther *University of Central Oklahoma*

Hopkins,Britney *University of Central Oklahoma*

Karber,Kristi *University of Oklahoma*

The CCA Urban ACT Prep Program was originally designed to assist low-income students by preparing them for the Mathematics portion of the ACT. Initially, we (UCO tutors) created ACT practice exams to help gauge the high school students' proficiency level. Through the results, we found that the younger high school students did not understand basic mathematical concepts fundamental to success on the ACT. Therefore, we created new material that focused on preparing the younger students for the Algebra I EOI. In addition, we used innovative tutoring techniques to address these issues. We are observing promising results each week we see the students.

05.13.09 Traveling Wave Solutions of Infectious Diseases Model

Yoon,Jeein *Cameron University*

Infectious diseases are caused by pathogens and are spread from person to person through coughing, sneezing, exchange of bodily fluids, etc. Epidemic diseases such as the Asian flu, polio, and the ongoing HIV/AIDS epidemic have had devastating effects globally. Mathematical models developed of these infectious diseases can be used to better understand the spatial spread and the minimum speed at which these diseases can spread from region to region. The objective of this research project is to find a traveling wave solution of an infectious diseases model and later fix upon a specific infectious disease. Analytical solutions of the SIR model have been solved and a system of diffusion type partial differential equations involving a spatial domain and time have been developed. Solving this system of PDEs, the minimum speed at which the infectious disease spreads has been established.

05.13.10 Cellular Models of Canine Parvovirus

Myers,Brittany *University of Central Oklahoma*

Parvovirus is a virus that infects actively dividing cells in many animals, including dogs. Canine Parvovirus type 2 (CPV2) has two forms, intestinal and cardiac, which often kill young dogs when they become infected. We built differential equations models to better understand how CPV2 infects host cells. The model includes viruses, infected cells, target cells, protected cells, and antibodies. Since there are multiple ways antibodies inhibit infection, we built two different models to study the different types of antibody response. Based on our model results, we propose the most effective method for fighting off CPV2 after infection.

05.13.11 Hermite Polynomials

Clymer,Maranda *East Central University*

We investigate the n-dimensional Hermite polynomials. Beginning with the general multivariate normal, we will build the most general Hermite Polynomials. This process starts by taking partial derivatives. Once we have taken partial derivatives, we are able to define the Hermite polynomials. Then, we are able to calculate for different values of n. If we take n partial derivatives, we then get one entry for an n-tensor. We examine multiple properties of the polynomials, such as their orthogonality and symmetry. Finally, we restrict the Hermite polynomials to one-dimension. With the assumption of mean zero and standard deviation one, we recover the traditional Hermite Polynomials.

05.13.12 Explorations of Complex Transformations

Godfrey,Micah *East Central University*

A transformation, in reference to mathematics, is a general way to describe a change in a point, a line or a shape. Transformations among the set of real numbers can be explained rather easily, both algebraically and visually, but transformations among the set of complex numbers can become quite complicated. This is in part due to complex numbers having two components: a real component and an imaginary component; while a real number has only one component, which is the number itself. Using complex numbers, we will investigate the changes that take place to a straight line under a polynomial transformation. In this investigation, we will explore loops, changes in direction, twists, intercepts, points of intersection, and different angles that are created by these polynomial transformations. We will use visual representation as well as algebraic representation to show the different changes made by these transformations within the set of complex numbers.

05.13.13 Comparison of Numerical Solutions of Black-Scholes Option Pricing Model.

Joshi,Ayush *Cameron University*

Kadel,Gokul *Cameron University*

Thapa,Narayan *Cameron University*

Brown,Bethany *Other*

Philip,Timothy *Other*

We studied the Solve-It Math Game, which is a math twist on Connect Four. There are many differences between this game and Connect Four, the most important being that numbers are meaningful rather than colors. We determined which scores are possible and which scores are impossible to achieve, and we studied whether or not there is a playing strategy that guarantees a win to a particular player. We found that the decisive factor is whether a player goes first or second.

05.13.15 Optimal Routing of Crude Oil Truck Transport from Well to Depot

Paynter,Bradley *University of Central Oklahoma*

McCoy,Liliya *University of Central Oklahoma*

Oklahoma has always been rich in oil, leading to rise of hundreds of companies drilling oil-producing wells. Modern technologies (i.e. horizontal drilling) lead to great increase in oil production, however, there is not enough oil pipeline available to get the oil from the well site to the refineries. When pipelines are not available in the area, oil companies employ the services of the trucking industry to get the oil where it needs to go. Usually several trucking companies will bid for the right to haul oil from the well to the drop sites and the oil companies will pick the best rates for them. The well sites have a holding tank (central tank battery) which typically holds 400 barrels of oil, once the tank battery reaches a certain number of barrels, the trucking company gets a call informing them that the oil is ready for pick up at the specific site. The driver of the truck chooses where to take a load of oil. The question arose of whether the trucking companies are choosing a route that is of minimum cost to the oil company. This question is explored through integer programming and preliminary results are presented.

05.13.16 Optimizing Strategic Decisions in "Settlers of Catan" using Linear Programming

Paynter,Bradley *University of Central Oklahoma*

Blanton,Corrin *University of Central Oklahoma*

Grounds,Chad *University of Central Oklahoma*

Legg,Peyton *University of Central Oklahoma*

Pak,Cameron *University of Central Oklahoma*

Steele,Kyle *University of Central Oklahoma*

Washburn,Shane *University of Central Oklahoma*

Fulkerson,Michael *University of Central Oklahoma*

We investigate a generalization of the factorial function, called the gamma function, and we show how it can be used to derive hypervolume and surface area formulas for a ball of radius r in n-dimensional Euclidean space. A peculiar result is that the hypervolume of the unit ball is greatest in dimension 5.

05.13.18 Maximizing Guaranteed Value in a Fair Division of a Cake under Piecewise-Linear Valuations.

Payne,Brandon *Cameron University*

Fulkerson,Michael *University of Central Oklahoma*

Balch,Brenden *University of Central Oklahoma*

Papayik,Jason *University of Central Oklahoma*

Some real improper integrals that are difficult or impossible to evaluate using ordinary calculus techniques can be evaluated using residue theory from complex analysis. We examine these techniques and provide some of the mathematical background, including Laurent series, the residue theorem, and their historical development. Finally, we give some concrete examples.

05.13.20 The Riemann Hypothesis - A Historical Examination

Fulkerson,Michael *University of Central Oklahoma*

Sharp,Christopher *University of Central Oklahoma*

The celebrated Riemann Hypothesis is considered by many mathematicians to be the most important unsolved problem in mathematics. We examine the historical background of the problem, including its connection to the Prime Number Theorem, as well as contributions from Euler, Gauss, Riemann, Hilbert, and others. We also investigate more recent modes of attack on the problem.

05.13.21 Arcs and Strongly Regular Graphs

Lane-Harvard,Liz *University of Central Oklahoma*

Various generalized quadrangles have been constructed from ovals, hyperovals, and q-arcs in Desarguesian projective planes. The concurrency (and collinearity) graph of a generalized quadrangle is a strongly regular graph. Thus, each of the above generalized quadrangles is associated with a strongly regular graph. Removing the hypothesis that the plane is Desarguesian, we construct strongly regular graphs with the same parameters as the concurrency graphs of the generalized quadrangles arising from ovals, hyperovals, and q-arcs.

05.13.22 Fair Division of a Shareable Good

Wimer,Natalie *Cameron University*

In a classic fair division problem, a resource (such as a cake) must be divided among multiple people to ensure that each person receives their fair share. Some resources, such as time or money, can not only be divided, but can also be shared, meaning that a portion can be assigned joint ownership or allocated in a mutually agreeable way. Each person may receive a portion all to his- or herself, while some other portions may be jointly owned by multiple people. We assume that joint ownership of a portion of the resource results in a proportionally lower satisfaction than sole ownership. We consider a problem of how best to divide a shareable resource between two people to ensure both people receive a fair level of satisfaction.

05.13.23 Predicting Clinical Treatment Outcome with Mathematical Models of a Novel Cancer Immunotherapy

Laverty,Sean *University of Central Oklahoma*

Dawkins,Bryan *University of Central Oklahoma*

The benefits of using lasers and immune stimulants to initiate a systemic anti-tumor immune response have been known for years. In successful treatments, immune cells work together to destroy all primary and metastatic tumors and cured patients develop long-term immunity against tumors. However, a major obstacle to successful treatment is the suppression of the anti-tumor immune response by pro-tumor regulatory T cells (Tregs). Though the exact immune mechanism responsible for antitumor activity is not entirely known, we have proposed an immune response that relies on antigen-presenting dendritic cells and tumor-killing cytotoxic T cells. The treatment is characterized by three essential factors: laser irradiation, a light absorbing dye, and an immune stimulant called glycated chitosan (GC). Our dynamical model is based on work done with the DMBA-4 metastatic mammary tumor line in rats. Treatment outcome is related to the strength of pro-immune stimulatory effects of GC and with the strength of pro-tumor Treg activity. We will show how clinical outcomes change as a function of these two competing forces and use our results to suggest useful experiments that may further improve treatment success.

05.13.24 Analyzing Neuron Dynamics with Mathematical Models

Laverty,Sean *University of Central Oklahoma*

Kalantari,Farzan *University of Central Oklahoma*

Using a system of differential equations, we describe the behavior of neurons. Neurons communicate through action potentials created by highly regulated fluctuations of ion concentrations. We describe the dynamics of voltage and gating strength, where ion-gated channels are used to close or open pathways for the flow of ions. The axon of a neuron is covered by a myelin sheath, keeping the neuron insulated to ensure rapid current flow. There are gaps along the myelin sheath, the Nodes of Ranvier, where the ion-gated channels reside; thus, the action potential must be reproduced at these nodes to continue signal propagation. By extending the FitzHugh-Nagumo neuron model, we developed a model which incorporates action potential propagation along the axon and can be used to study neural function in demyelination disorders.

05.13.25 Asymptotic Behavior of the Prime Counting Function

Fulkerson,Michael *University of Central Oklahoma*

Alasafra,Hussain *University of Central Oklahoma*

The Prime Number Theorem (PNT) states that the number of primes less than a given value x is asymptotically equal to x/log(x). The PNT was conjectured by Gauss when he was 15 years old, but it was finally proved over 100 years later (in 1896) by Hadamard and de la Valee-Poussin. We explore the history of the PNT as well as results related to the prime counting function, the logarithmic integral function, and the zeta function.

05.13.26 Parameter Estimation Problem in Projectile Motion.

KARKI,NISHAN *Cameron University*

Rana,Jashmon *Cameron University*

Thapa,Narayan *Cameron University*

Identification problems are one of the oldest most important problem in mathematics and engineering. Because of their applications in medical imaging, underground prospecting, nondestructive testing, astronomical imaging, image processing, remote sensing, and data mining, the Business, Industry, and government (BIG) sectors are very interested in applied inverse problems. In this project, we work on a simple yet powerful identification problem for projectiles. In particular, we are interested in finding the optimal angle for launching a projectile to maximize the distance it travels. In order to accomplish this, we develop a system of second order initial value type model. The system of second order initial value problems will be solved by using ordinary differential equations routine. In addition to this, functional related with predicted and observed data will be established and minimized over the space of admissible set of parameters. MATLAB routine will be used to estimate parameters.

05.13.27 Parameter Estimation Problem in Projectile Motion

Rana,Jashmon *Cameron University*

Identification problems are one of the oldest most important problem in mathematics and engineering. Because of their applications in medical imaging, underground prospecting, nondestructive testing, astronomical imaging, image processing, remote sensing, and data mining, the Business, Industry, and government (BIG) sectors are very interested in applied inverse problems. In this project, we work on a simple yet powerful identification problem for projectiles. In particular, we are interested in finding the optimal angle for launching a projectile to maximize the distance it travels. In order to accomplish this, we develop a system of second order initial value type model. The system of second order initial value problems will be solved by using ordinary differential equations routine. In addition to this, functional related with predicted and observed data will be established and minimized over the space of admissible set of parameters. MATLAB routine will be used to estimate parameters.